

Bayesian estimation of surface parameters from remote sensing data

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Abstract:

We consider the problem of finding a mathematically optimal algorithm to estimate surface parameters based on radar and/or other measurements. Specifically, given measurements m_1, m_2, \dots, m_J representing radar cross-sections of a given resolution element at different polarizations and/or different frequency bands, and given an approximate model expressing the dependence of these measurements on the dielectric constant ϵ , the r.m.s. surface height h and, eventually, the canopy water content w of the corresponding resolution element, we would like to make an "optimal" estimate of the actual ϵ , h and w that gave rise to the particular m_1, m_2, \dots observed. By "optimal" we mean that our algorithm should produce estimates that are, on average, as close as possible to the actual values. To obtain such an algorithm, we assume that we have at our disposal a data catalogue consisting of *calibration* measurements of the surface parameters ϵ , h and w , on one hand, and the corresponding remote sensing data m_1, m_2 etc, on the other. We also assume that we have used this data to write down, for each j , an approximate model which computes an average value of m_j to associate to the corresponding values of (ϵ, h, w) . Rather than throw away the **data** catalogue at this stage, and use the average formulas in a deterministic fashion to **soil** ("the inverse problem"), we **propose** to use the data catalogue more fully and quantify the spread of the measurements about the average formula, then incorporate this information into the inversion algorithm. This paper describes how we accomplish this using a Bayesian approach. We have already applied our method to bare soils. In this case, we are able to

- 1) make an optimal estimate of ϵ and h
- 2) place a quantitatively honest error bar on each estimate, as a function of the actual values of the remote sensing measurements
- 3) fine-tune the initial formulas expressing the dependence of the remote sensing data on the soil parameters

4 take into account as many (or as few) remote sensing measurements as we like in making our estimates of ϵ , h and w , in each case producing error bars to quantify the benefits of using a particular combination of measurements.

We also describe how the method can be extended to account for vegetation and to estimate the canopy water content w along with ϵ and h .

Biography: Ziad S. Laddad

Ziad S. Laddad received the B.A. degree in Mathematics and Computer Science from UCLA in 1980, and the Ph.D. degree in Mathematics from the Massachusetts Institute of Technology in 1983. After a NSF post-doctoral research fellowship at the Mathematical Sciences Research Institute in Berkeley, CA, he returned to MIT to teach in the mathematics department and pursue applied research in radar detection and tracking at MIT's Lincoln Laboratory. He then joined AT&T Bell Laboratories to work on wave propagation modeling from 1986 to 1988, at which time he joined the mathematics department at the University of California at San Diego and UCSD's Center for Studies of Nonlinear Dynamics, where he pursued his research in modeling wave propagation and developing new methods in nonlinear filtering and estimation. He has been with JPL since 1991. His current research interests include the development of stochastic algorithms for the retrieval of precipitation and the estimation of soil parameters from remote sensing data.